

CLAIMS

1. Apparatus for controlling the deformation of an implant during deployment thereof, comprising:

a force application mechanism for applying deforming force to the implant, by axial motion of a force applicator against the implant; and

a restraint element positioning mechanism that positions a restraining element such that the deformation of the implant is controlled by restraint of the restraining element on allowable deformation; and

10 a synchronizer that synchronizes the motion of the restraining element and the force applicator, to achieve a desired deformation of the implant.

15 2. Apparatus according to claim 1, comprising a force input which receives continuous motion and couples it to the force application mechanism and to the restraint element positioning mechanism.

3. Apparatus according to claim 2, wherein said continuous motion is reciprocating motion.

20 4. Apparatus according to claim 3, wherein said restraint positioning mechanism moves said restraint element during one stroke of said reciprocating motion.

5. Apparatus according to claim 4, wherein said one stroke comprises a retraction of said restraint mechanism from said implant.

25 6. Apparatus according to any of claims 3-5, wherein said force application mechanism moves said force applicator during one stroke of said reciprocating motion.

30 7. Apparatus according to claim 6, wherein said one stroke comprises a retraction of said force applicator from said implant.

8. Apparatus according to claim 6, wherein said one stroke comprises an advance of said force applicator towards said implant.

9. Apparatus according to any of claims 2-8, wherein said force application mechanism comprises a selective coupler that selectively couples said input motion to said force applicator.

10. Apparatus according to any of claims 2-9, wherein said element positioning mechanism comprises a selective coupler that selectively couples said input motion to said restraining element.

11. Apparatus according to any of claims 2-10, wherein said synchronized motion is repetitive, comprises a plurality of cycles of positioning said restraining element and applying said force.

12. Apparatus according to any of claims 2-11, wherein said motion is applied simultaneously to said restraint element positioning mechanism and to said force application mechanism.

13. Apparatus according to any of claims 2-11, wherein said motion is applied alternately to said restraint element positioning mechanism and to said force application mechanism.

14. Apparatus according to claim 13, comprising an alternating locking mechanism that alternately couples the motion from the force input to the restraint element positioning mechanism and to the force application mechanism.

15. Apparatus according to any of claims 2-14, wherein said force input comprises a manual force input.

16. Apparatus according to any of claims 2-14, wherein said force input comprises a motorized force input.

17. Apparatus according to any of claims 1-16, wherein said synchronizer is integrated with said mechanisms.

18. Apparatus according to any of claims 1-17, wherein said synchronizer is manual, providing an indication to an operator to switch between the mechanisms.

19. Apparatus according to any of claims 1-17, wherein said synchronizer is automatic, switching by itself between the mechanisms.

20. Apparatus according to any of claims 1-19, wherein said synchronizer comprises a pin extractor for decoupling a pin from one mechanism and coupling the pin to another mechanism.

21. Apparatus according to claim 20, wherein said synchronizer comprises a spring for urging said pin towards one of said mechanisms and an inclined plane for withdrawing said pin from said one mechanism and urging said pin towards said other mechanism.

22. Apparatus according to any of claims 1-21, wherein said synchronizer blocks the motion of one of said mechanisms when a desired motion effect of said mechanism is achieved.

23. Apparatus according to claim 22, comprising a pin that engages an aperture to effect said locking.

24. Apparatus according to any of claims 1-23, wherein said restraint mechanism comprises an unevenly surfaced element for coupling said motion to said restraint element.

25. Apparatus according to any of claims 1-24, wherein said force application mechanism comprises an unevenly surfaced element for coupling said motion to said force applicator.

26. Apparatus according to any of claims 24-25, wherein said unevenly surfaced element comprises a nubbed plate.

27. Apparatus according to claim 26, wherein said nubs are one-way nubs that allow an arm element of said mechanisms to slip over them when the arm travels in one direction relative to the nubs and engages the arm when the arm travels in the opposite relative direction.

28. Apparatus according to any of claims 24-25, wherein said unevenly surfaced element comprises an apertured plate.

29. Apparatus according to any of claims 24-28, wherein said uneven surface comprises even surface portions separated, by uneven surface portions, a plurality of separation distances defined by said separation of surface portions.

30. Apparatus according to claim 29, wherein said separation distances determine the deformation of said implant.

31. Apparatus according to claim 29 or claim 30, wherein said separation distances take into account a plastic deformation of said implant.

32. Apparatus according to any of claims 29-31, wherein said separation distances take into account an elastic deformation of said implant.

33. Apparatus according to any of claims 29-31, wherein said separation distances take into account a spring-back of said implant.

34. Apparatus according to any of claims 1-33, wherein said force applicator and said force application mechanism are substantially restricted to a straight, narrow, elongate volume, thereby reducing moments on the force application mechanism.

35. Apparatus according to any of claims 1-34, wherein said force applicator pushes against said implant.

36. Apparatus according to any of claims 1-34, wherein said force applicator pulls a base against a far side of said implant.

37. Apparatus according to any of claims 1-36, wherein said force applicator exhibits axial motion, along an axis connecting the force applicator and the implant.

38. Apparatus according to any of claims 1-37, wherein said force applicator exhibits rotational motion, around an axis connecting the force applicator and the implant.

39. Apparatus according to claim 37, wherein said force applicator exhibits only axial motion, along an axis connecting the force applicator and the implant.

40. Apparatus according to any of claims 1-39, wherein said restraint element exhibits axial motion, along an axis connecting the force applicator and the implant.

41. Apparatus according to any of claims 1-40, wherein said restraint element exhibits rotational motion, around an axis connecting the force applicator and the implant.

42. Apparatus according to claim 40, wherein said force applicator exhibits only axial motion, during times when force is applied by it to the implant, along an axis connecting the force applicator and the implant.

43. Apparatus according to any of claims 1-42, wherein said force applicator applies at least 20 Kg to said implant.

44. Apparatus according to any of claims 1-42, wherein said force applicator applies at least 40 Kg to said implant.

45. Apparatus according to any of claims 1-42, wherein said force applicator applies at least 60 Kg to said implant.

46. Apparatus according to any of claims 1-42, wherein said force applicator applies at least 100 Kg to said implant.

47. Apparatus according to any of claims 1-46, wherein said restraint element and said force applicator are elongate elements.

48. Apparatus according to claim 47, wherein said restraint element and said force applicator are cylindrical elements.

49. Apparatus according to claim 47 or claim 48, wherein said cylindrical elements are tubes.

50. Apparatus according to any of claims 1-49, wherein said force applicator comprises two concentric elements, an outer element which applies force away from said apparatus towards said implant and an inner counter force element that applies force from said implant towards said apparatus.

51. Apparatus according to claim 50, wherein said inner element is mechanically coupled to said implant.

52. Apparatus according to claim 50, wherein said outer element is mechanically coupled to said implant.

53. Apparatus according to any of claims 50-52, wherein said motion of said force applicator comprises motion of only one of said concentric elements relative to said apparatus.

54. Apparatus according to claim 53, wherein said inner element retracts towards said apparatus during said motion of said force applicator.

55. Apparatus according to claim 53, wherein said outer element advances away from said apparatus during said motion of said force applicator.

56. Apparatus according to any of claims 50-55, wherein said inner element is decoupled from said implant by unscrewing it.

57. Apparatus according to claim 56, wherein said inner element extends substantially all the way through said apparatus.

58. Apparatus according to any of claims 1-57, comprising a handle for holding said apparatus by an operator.

59. Apparatus according to any of claims 1-58, comprising means for fixing said apparatus to said patient.

70. Apparatus according to any of claims 1-66, wherein said implant comprises a slotted tube, to which force is applied against an end of said tube, to deform the tube.

71. Apparatus according to any of claims 1-66, wherein said implant radially expands by said deforming at least by a ratio of two.

72. Apparatus according to any of claims 1-66, wherein said implant radially expands by said deforming at least by a ratio of four.

73. A method of controlling the deformation of an implant, comprising:
providing a medical implant;
positioning a restraining element relative to said implant, which restraining element prevents deformation of at least some of said implant;
applying a deformation force to said implant using at least one tube;
controlling the deformation of the implant using the restraining element;
moving said restraining element to a new position; and
repeating said applying, said controlling and said moving, a plurality of times.

74. A method according to claim 73, wherein said deformation comprises radial expansion.

75. A method according to claim 73 or claim 74, wherein said restraining element is inside said implant.

76. A method according to claim 73 or claim 74, wherein said restraining element is outside said implant.

77. A method according to any of claims 73-76, wherein said motion of said restraining element is controlled using a mechanism external to the implant.

78. A method according to claim 77, wherein said external mechanism receives a continuous motion input from an operator.

79. A method according to claim 78, comprising converting said continuous motion into discrete motion of said restraining element.

80. A method according to claim 78 or claim 79, comprising converting said continuous motion into discrete application of force to said implant.

81. A method according to any of claims 73-80, wherein said motion and said force application do not overlap in time.

82. A method according to any of claims 73-80, wherein said motion and said force application do overlap in time.

83. A method of controlling the deformation of an implant, composing:

providing an axial implant having a plurality of spikes extending radially thereto, arranged along the implant's axis, which implant is in a collapsed state where said spikes do not extend;

enclosing said implant with a collar that restrains the extension of said spikes;

inserting said implant into a desired location;

retracting said collar to allow at least one spike to extend; and

repeating said retracting until substantially all of said spikes are extended.

84. A method according to claim 83, wherein said spikes extend as a result of forces stored within said implant.

85. A method according to claim 84, wherein said implant is formed of a super-elastic material.

86. A method according to claim 84, wherein said implant is formed of a shape-memory material.

87. A method according to claim 83, wherein said spikes extend as a result of forces applied externally to said implant.

88. A method according to claim 87, wherein said forces are axially applied to said implant.

89. A method according to claim 88, comprising applying an axial force to said implant after all of said spikes are extended.

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5 90. A measurement apparatus for taking measurements inside the body, comprising:
a hollow tube, defining at least one slot at its end;
a shaft disposed within said tube; and
at least one wing coupled to said shaft and adapted to extend through said slot, wherein
an extension position of said wing determines an axial motion of said shaft in said tube,
wherein said apparatus is adapted to come in contact with body fluids and wherein said
10 apparatus is sterile.

91. Apparatus according to claim 90, wherein said apparatus is sterilizable.

92. Apparatus according to claim 90 or claim 91, wherein said tube comprises defines at
15 least two slots and wherein said at least one wing comprises at least two wings.

93. Apparatus according to any of claims 90-92, wherein extension of said wings retracts
said shaft towards said wings.

20 94. Apparatus according to any of claims 90-92, wherein extension of said shaft away from
said wings extends said wings.

95. Apparatus according to any of claims 90-94, wherein said wings are molded from a
single piece of plastic.

25 96. Apparatus according to any of claims 90-95, wherein said at least one wing defines a
parallelogram, with the shaft attached to one vertex of the parallelogram and the two
neighboring vertexes of the parallelogram comprises the extended parts of two wings.

30 97. Apparatus according to any of claims 90-95, comprising a dial coupled to said shaft
and displaying an extension of said wings as a function of a relative displacement between said
shaft and said tube.

60. Apparatus according to any of claims 1-59, comprising means for fixing said apparatus to a bed on which said patient lies.

5 61. Apparatus according to any of claims 1-60, wherein said synchronizer adapts said apparatus for deforming a particular implant from a set of same types of implants having different geometries.

10 62. Apparatus according to any of claims 1-61, wherein said synchronizer synchronizes said force applicator to apply force to said implant after said implant is completely expanded.

63. Apparatus according to any of claims 1-62 wherein said restraint element has an outer diameter of less than 7 mm.

15 64. Apparatus according to any of claims 1-62 wherein said restraint element has an outer diameter of less than 6 mm.

65. Apparatus according to any of claims 1-62 wherein said restraint element has an outer diameter of less than 5 mm.

20 66. Apparatus according to any of claims 1-62 wherein said restraint element has an outer diameter of less than 4 mm.

25 67. Apparatus according to any of claims 1-66, wherein said implant is a spinal implant for fusing adjacent vertebrae.

68. Apparatus according to any of claims 1-66, wherein said implant is an axially contracting and radially expanding implant.

30 69. Apparatus according to any of claims 1-66, wherein said implant comprises a slotted tube, which as it contracts, radially extends a plurality of spikes and wherein said restraining element encloses said tube and prevents the extension of at least one of said spikes.

